JCM
Journals.ASM.org

# Reducing Unnecessary and Duplicate Ordering for Ovum and Parasite Examinations and *Clostridium difficile* PCR in Immunocompromised Patients by Using an Alert at the Time of Request in the Order Management System

Caitlin C. Otto,[a] Susan L. Shuptar,[a] Philippe Milord,[b] Connor J. Essick,[c] Reshma Nevrekar,[d] Svetlana L. Granovsky,[e] Susan K. Seo,[f] N. Esther Babady,[a] Steven C. Martin,[f] Yi-Wei Tang,[a] Melissa S. Pessin[c]

Clinical Microbiology Service, Department of Laboratory Medicine,[a] Patient Accounts,[b] Department of Laboratory Medicine,[c] Clinical Systems Administration,[d] Department of Quality and Safety,[e] and Infectious Diseases Service, Department of Medicine,[f] Memorial Sloan Kettering Cancer Center, New York, New York, USA

**We implemented hospital information system (HIS) alerts to deter unnecessary test orders for ovum and parasite (O&P) exams and *Clostridium difficile* PCR. The HIS alerts decreased noncompliant O&P orders (orders after >72 h of hospitalization) from 49.8% to 30.9%, an overall decrease of 19%, and reduced noncompliant *C. difficile* PCR orders (orders <7 days after a previous positive result) from 30.6% to 19.2%, an overall decrease of 31.9%.**

Immunocompromised patients frequently present with acute diarrhea due to an unknown etiology. In this patient population, diarrhea may be related to chemotherapy, graft-versus-host disease, antibiotics, other medications, (e.g., laxatives), or infectious disease agents; thus, clinically distinguishing between these causes can be difficult (1). Furthermore, these patients are at a higher risk for complications from infectious causes of gastroenteritis (2), highlighting the importance of correct and timely laboratory testing (1). On the other hand, unnecessary and duplicate testing can result in additional expenses, laboratory workloads, and burdens on patients and related hospital staff (3, 4).

*Clostridium difficile* infection (CDI) is one of the most common hospital-acquired infections and is an increasingly frequent cause of morbidity and mortality in hospitalized patients (5). CDI can lead to colitis, toxic megacolon, and even death (6); it is linked to more than a half million infections and 14,000 deaths each year in the United States (7). PCR testing has become the test of choice for the diagnosis of CDI; however, numerous studies have demonstrated that repeat *C. difficile* PCR testing, especially within the first 7 days of an initial positive test, does not change the test result in 97% to 99% of patients. Furthermore, repeat testing within 48 h of a negative result changed the result in only 1.9% of patients (8). In both cases, overordering these tests has been shown to lead to increased hospital costs and potential false-positive results (3, 4, 9).

Gastroenteritis can also be caused by a number of parasitic pathogens, including *Giardia lamblia* and *Cryptosporidium* species. Ovum and parasite (O&P) exams are an effective tool for identifying infections caused by these organisms; however, the utility of the O&P exam in patients with long-term hospital stays has been called into question. A number of studies have shown that the differential diagnoses for infectious causes of hospital-acquired versus community-acquired infections have great differences. For example, for community-acquired diarrhea, it is reasonable to consider parasitic infections or bacterial infections from organisms such as *Salmonella*, *Shigella*, or *Campylobacter*; these organisms have rarely been shown to cause hospital-acquired infections except in rare outbreaks of food poisoning (10, 11). Seigel et al. evaluated the positivity rates of O&P examinations in patients with fewer than 3 days of hospitalization compared to those with greater than 3 days of hospitalization (12). In this study, none of the samples submitted from patients with greater than 3 days of hospitalization were positive, demonstrating that there is no utility to testing for O&P in patients whose hospital stay is longer than 3 days (13). Another study by Kamboj et al. (14) demonstrated little utility of the O&P exam in early (day −10 to day 30) or late (day 31 to day 90) post-hematopoietic stem cell transplant periods. The authors suggested that testing for O&P in this population is futile unless there is clinical or epidemiological data suggesting parasitic infection, such as the presence of *Strongyloides* (14). Furthermore, testing for O&P after 3 days of hospitalization is not recommended by the Infectious Diseases Society of America (IDSA) or the American Society for Microbiology (ASM) (15). Therefore, the relatively time-consuming O&P exam should only be reserved for outpatients, those who are admitted to the hospital for a diarrheal illness caused by a community-acquired infection, or immunocompromised patients with suspicion of *Strongyloides* infection regardless of admission length (12, 16).

(This study was presented in part at the Association for Molecular Pathology Annual Meeting, National Harbor, MD, 12 to 15 November 2014.)

Our institution is a specialized cancer center in which many

**Received** 9 April 2015 **Returned for modification** 8 May 2015
**Accepted** 4 June 2015
**Accepted manuscript posted online** 10 June 2015
**Citation** Otto CC, Shuptar SL, Milord P, Essick CJ, Nevrekar R, Granovsky SL, Seo SK, Babady NE, Martin SC, Tang Y-W, Pessin MS. 2015. Reducing unnecessary and duplicate ordering for ovum and parasite examinations and *Clostridium difficile* PCR in immunocompromised patients by using an alert at the time of request in the order management system. J Clin Microbiol 53:2745–2748. doi:10.1128/JCM.00968-15.
**Editor:** P. H. Gilligan
Address correspondence to Yi-Wei Tang, tangy@mskcc.org.

doi:10.1128/JCM.00968-15

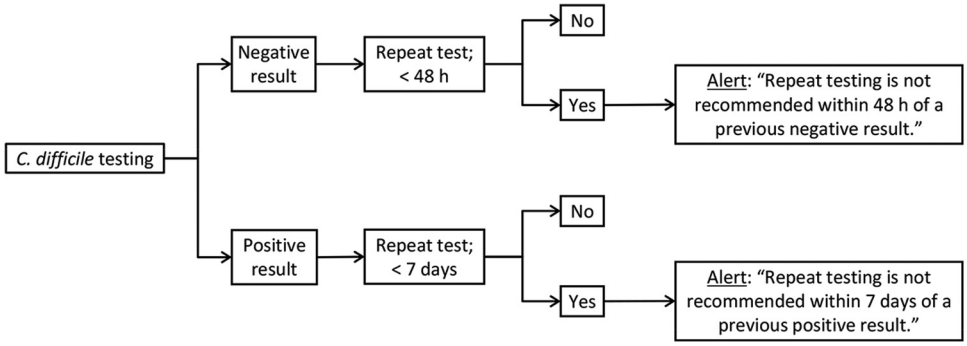


**FIG 1** Flow chart for the *C. difficile* order alert algorithm. Order alerts appear if a physician attempts to order a test that meets the noncompliance criteria.

patients are hospitalized for long periods of time and have idiopathic diarrhea. To test for possible parasitic infections, our laboratory provides a full O&P analysis with trichrome staining. In September 2010, the clinical microbiology laboratory implemented the Cepheid Xpert *C. difficile* assay (Cepheid, Sunnyvale, CA) (17). With the change in testing methodology combined with the long hospital stays of this population, we observed increased unnecessary orders for *C. difficile* PCR. As a cost-savings and quality-improvement project, we implemented four alerts in the hospital information system (HIS) with the overall goal to decrease unnecessary and duplicate ordering for *C. difficile* PCR and O&P exams (Fig. 1). The alerts were deployed on May 13, 2013, and were as follows: (1) *C. difficile* testing is not recommended within 7 days after a positive result (2); *C. difficile* testing is not recommended within 48 h of a previous negative test (3); testing stool in an O&P exam is not recommended for patients who have been hospitalized for more than 72 h (4); and infectious disease consultation approval is required for these orders. The appropriate alert appeared in the HIS test ordering window when a patient had either a negative *C. difficile* result within the last 48 h or a positive result within the last 7 days, or when ordering an O&P exam if the patient had been admitted to the hospital for greater than 72 h. Finally, if the physician moved forward with ordering a noncompliant test, an additional message was displayed with instructions to obtain approval from an infectious disease physician if the user believed that testing was necessary. The ordering physician was then required to enter the name of the person who approved the order before proceeding. In this study, we measured the impact of the alerts by reviewing and analyzing the overall test volumes and the rates of compliance with test orders for 12 months before and 12 months after implementation of these alerts.

Overall, the O&P ordering volume decreased after implementing the order alerts. The average (± standard deviation) monthly inpatient O&P orders decreased from 89.9 ± 21.5 per month to 33.5 ± 6.3 per month (a 63% decrease) before and after, respectively, the May 13, 2013, go-live date. The average (± standard deviation) monthly number of noncompliant O&P orders, or those placed after 72 h of a patient being hospitalized, was reduced from 47 ± 13 (33.5%) to 10 ± 5 (12.9%), an overall decrease of 58.7% ($P = 0.0000$). There was a corresponding increase in compliant samples from 49% compliant to 72% compliant (Fig. 2A). Furthermore, the average (± standard deviation) rate of positive O&P exams was significantly increased from 1.5% ± 0.02% to 3.8% ± 0.04% ($P = 0.0488$) following implementation of the order alerts (Fig. 2A). It is important to note that all of the noncompliant tests completed after implementing the order alerts were negative.

In the year following the alerts implementation, the overall average (± standard deviation) volume of monthly *C. difficile* orders increased from 401.9 ± 155.98 to 476.69 ± 46.9 orders per month (an 18.6% increase). Despite the increase in test order volume, the overall number of noncompliant orders decreased from 4.0% to 2.6% ($P = 0.039$). Prior to the order alerts, only 2 of 2,273 (0.09%) orders were requested within 48 h of a negative result; however, after we implemented the order alerts, there were 0 of 3,743 (0%) sample tests ordered within 48 h of a negative result. With respect to the noncompliant orders following a previous positive result, an average of 30.6% of samples (104 of 340 samples) were noncompliant each month prior to alert implementation, meaning that a second *C. difficile* order was requested within 7 days of a previous positive sample. However, after implementing the order alerts, the average monthly rate of noncompliant sample orders was reduced to 19.2% (81 of 422 sample orders), an overall decrease of 31.9% ($P = 0.028$). Figure 2B summarizes the overall changes in sample volume and the number of compliant samples before and after implementing the alerts.

Unnecessary laboratory orders impose significant financial and workload burdens onto clinical laboratories (3, 4). Some laboratories have taken different strategies to decrease unnecessary *C. difficile* testing by, for example, only accepting liquid stool samples for processing (15). However, previous studies have shown that computerized prompts are an important way of modifying physician behaviors. A systematic review of the literature by Schedlbauer et al. showed that 23 of 27 papers demonstrated benefit in improving prescribing behavior and/or reducing error rates by implementing computerized order alerts (18). Luo et al. (19) implemented a policy at their institution to reject repeat PCR testing for CDI within 7 days of an initial test except with the approval of the microbiology laboratory director. This group used a series of pop-up windows in the HIS ordering system that were triggered when a physician attempted to order a *C. difficile* PCR test within 7 days of a previous positive result. While this approach was shown to be an effective way to reduce duplicate ordering, a limitation of order alerts is that physicians often suffer from alert fatigue, whereby excessive warnings may cause them to pay less attention to vital alerts, thus limiting the effectiveness of these systems (20). In the system we applied here, the ordering physicians were unable to continue with a noncompliant order without consulting with an infectious disease physician. This strategy helped improve the efficacy of the alerts, but it still allowed order-

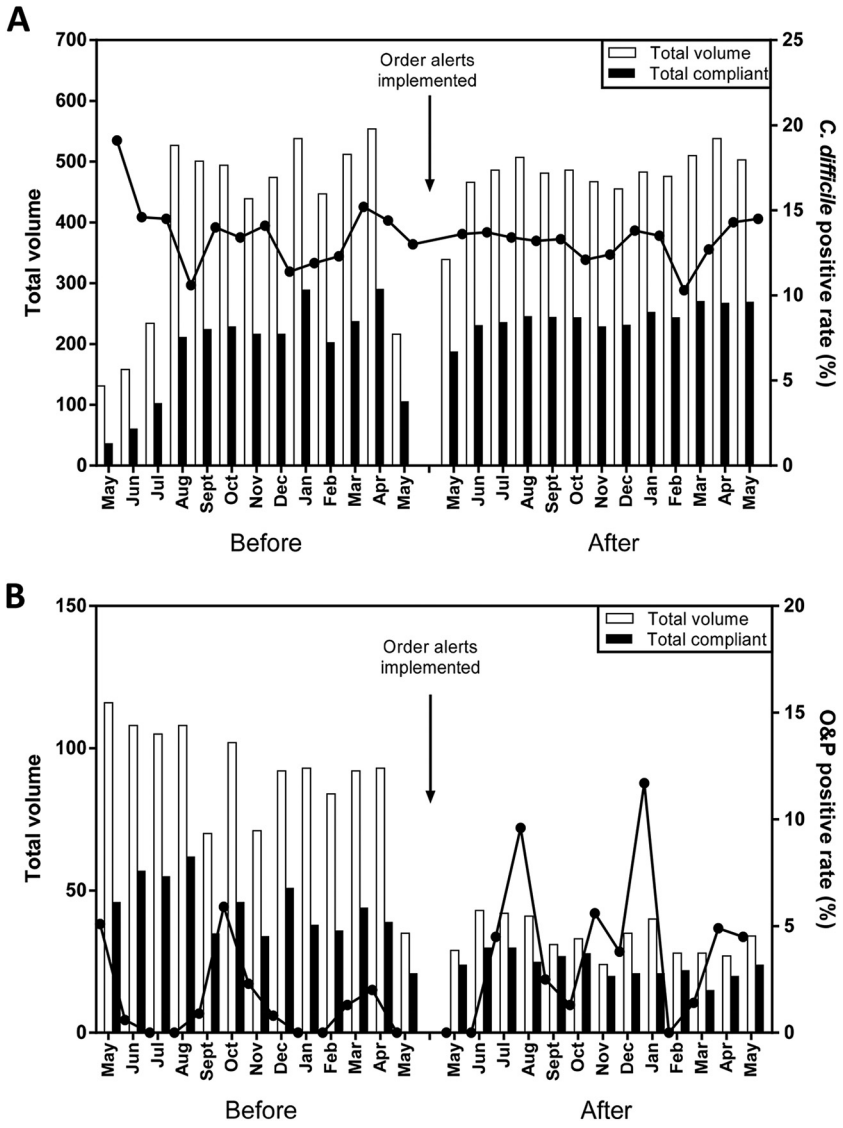


**FIG 2** Number of total samples (left axis), number of compliant samples (left axis), and the percent positive rate (right axis) for ovum and parasite (O&P) exam orders (A) and *C. difficile* testing (B). Noncompliant O&P orders are those placed after a hospital stay of >3 days. Noncompliant *C. difficile* orders are repeat orders placed within 7 days of a previous positive result or within 48 h of a previous negative result.

ing if it was clinically indicated. A cost analysis by Nistico et al. showed that the cost savings of reducing unnecessary *C. difficile* testing extends from the laboratory to other areas of the hospital costs, such as vancomycin usage, hospital isolation days, and other hospital-wide costs (4, 19). Here, we show that computerized alerts in the hospital order management system significantly reduced noncompliant *C. difficile* and O&P orders. The alerts in the hospital HIS reduced the noncompliant O&P exam orders by 58.7%. In addition, the order alerts reduced noncompliant *C. difficile* orders by 31.9% and 0.09% for repeat testing following a positive and a negative result, respectively. The repeat *C. difficile* testing following a negative test was not a problem prior to implementing the order alerts and, therefore, showed a minimal decrease in noncompliance. In conclusion, HIS order alerts are an effective approach to minimizing unnecessary and duplicate ordering of *C. difficile* and O&P exams in the hospital setting.

## ACKNOWLEDGMENTS

We thank laboratory staff in the Clinical Microbiology Service and clinical fellows in the Infectious Diseases Service at MSKCC for their excellent assistance. We also thank Ellinor Peerschke, Kent Sepkowitz, Eric Pamer, and Zenia Papanicolaou for their helpful thoughts and discussions.

## REFERENCES

1. **Ippoliti C.** 1998. Antidiarrheal agents for the management of treatment-related diarrhea in cancer patients. Am J Health Syst Pharm **55:**1573–1580.
2. **Freifeld AG, Bow EJ, Sepkowitz KA, Boeckh MJ, Ito JI, Mullen CA, Raad II, Rolston KV, Young J-AH, Wingard JR.** 2011. Clinical practice guideline for the use of antimicrobial agents in neutropenic patients with cancer: 2010 Update by the Infectious Diseases Society of America. Clin Infect Dis **52:**e56–e93. http://dx.doi.org/10.1093/cid/cir073.
3. **Aichinger E, Schleck CD, Harmsen WS, Nyre LM, Patel R.** 2008. Nonutility of repeat laboratory testing for detection of *Clostridium difficile* by use of PCR or enzyme immunoassay. J Clin Microbiol **46:**3795–3797. http://dx.doi.org/10.1128/JCM.00684-08.

4. **Nistico J, Hage J, Schoch P, Cunha B.** 2013. Unnecessary repeat *Clostridium difficile* PCR testing in hospitalized adults with *C. difficile*-negative diarrhea. Eur J Clin Microbiol Infect Dis **32:**97–99. http://dx.doi.org/10.1007/s10096-012-1719-2.
5. **Cohen SH, Gerding DN, Johnson S, Kelly CP, Loo VG, McDonald LC, Pepin J, Wilcox MH.** 2010. Clinical practice guidelines for *Clostridium difficile* infection in adults: 2010 update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA). Infect Control Hosp Epidemiol **31:**431–455. http://dx.doi.org/10.1086/651706.
6. **McDonald LC, Coignard B, Dubberke E, Song X, Horan T, Kutty PK, Ad Hoc *Clostridium difficile* Surveillance Working Group.** 2007. Recommendations for surveillance of *Clostridium difficile*-associated disease. Infect Control Hosp Epidemiol **28:**140–145. http://dx.doi.org/10.1086/511798.
7. **Frieden T.** 2013. Antibiotic resistance threats in the United States, 2013. Centers for Disease Control and Prevention, US Department of Health and Human Services, Washington, DC.
8. **Cardona DM, Rand KH.** 2008. Evaluation of repeat *Clostridium difficile* enzyme immunoassay testing. J Clin Microbiol **46:**3686–3689. http://dx.doi.org/10.1128/JCM.00931-08.
9. **Peterson LR, Robicsek A.** 2009. Does my patient have *Clostridium difficile* infection? Ann Intern Med **151:**176–179. http://dx.doi.org/10.7326/0003-4819-151-3-200908040-00005.
10. **Moreira LL, Netto EM, Nascimento-Carvalho CM.** 2009. Nosocomial gastroenteritis in children with and without rotavirus infection. Pediatr Infect Dis J **28:**72. http://dx.doi.org/10.1097/INF.0b013e31818ec288.
11. **Wenzel RP, Brewer TF, Butzler J-P.** 2002. A guide to infection control in the hospital, 2 ed. BC Decker, Inc., Lewiston, NY.
12. **Siegel DL, Edelstein PH, Nachamkin I.** 1990. Inappropriate testing for diarrheal diseases in the hospital. JAMA **263:**979–982. http://dx.doi.org/10.1001/jama.1990.03440070067034.
13. **Morris AJ, Wilson ML, Reller LB.** 1992. Application of rejection criteria for stool ovum and parasite examinations. J Clin Microbiol **30:**3213–3216.
14. **Kamboj M, Mihu CN, Sepkowitz K, Kernan NA, Papanicolaou GA.** 2007. Work-up for infectious diarrhea after allogeneic hematopoietic stem cell transplantation: single-specimen testing results in cost savings without compromising diagnostic yield. Transpl Infect Dis **9:**265–269. http://dx.doi.org/10.1111/j.1399-3062.2007.00230.x.
15. **Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB, Bourbeau P, Carroll KC, Kehl SC, Dunne WM.** 2013. A guide to utilization of the microbiology laboratory for diagnosis of infectious diseases: 2013 recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM). Clin Infect Dis **57:**e22–e121. http://dx.doi.org/10.1093/cid/cit278.
16. **Chitkara YK, McCasland KA, Kenefic L.** 1996. Development and implementation of cost-effective guidelines in the laboratory investigation of diarrhea in a community hospital. Arch Intern Med **156:**1445–1448. http://dx.doi.org/10.1001/archinte.1996.00440120103011.
17. **Babady NE, Stiles J, Ruggiero P, Khosa P, Huang D, Shuptar S, Kamboj M, Kiehn TE.** 2010. Evaluation of the Cepheid Xpert *Clostridium difficile* Epi assay for diagnosis of *Clostridium difficile* infection and typing of the NAP1 strain at a cancer hospital. J Clin Microbiol **48:**4519–4524. http://dx.doi.org/10.1128/JCM.01648-10.
18. **Schedlbauer A, Prasad V, Mulvaney C, Phansalkar S, Stanton W, Bates DW, Avery AJ.** 2009. What evidence supports the use of computerized alerts and prompts to improve clinicians' prescribing behavior? J Am Med Inform Assoc **16:**531–538. http://dx.doi.org/10.1197/jamia.M2910.
19. **Luo RF, Spradley S, Banaei N.** 2013. Alerting Physicians during electronic order entry effectively reduces unnecessary repeat PCR testing for *Clostridium difficile*. J Clin Microbiol **51:**3872–3874. http://dx.doi.org/10.1128/JCM.01724-13.
20. **Kesselheim AS, Cresswell K, Phansalkar S, Bates DW, Sheikh A.** 2011. Clinical Decision support systems could be modified to reduce alert fatigue while still minimizing the risk of litigation. Health Affairs **30:**2310–2317. http://dx.doi.org/10.1377/hlthaff.2010.1111.